SUMMARY OF AIR QUALITY MONITORING IN ALBERTA 1991

Technical Report Series

Alberta
ENVIRONMENT

SUMMARY OF AIR QUALITY MONITORING IN ALBERTA 1991

Prepared by:

R.H. Myrick

Air Assessment Section
Environmental Quality Monitoring Branch
Environmental Assessment Division
Alberta Environmental Protection

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This report is one in a series of air quality annual reports produced by Alberta Environmental Protection for 1991. The following air quality annual reports are available for 1991:

Summary of Air Quality Monitoring in Alberta: 1991.
Air Quality Monitoring Report for Alberta: 1991 - Technical Report Series No. 93-1a.
Air Quality Monitoring Data Summary for Alberta: 1991 - Technical Report Series No. 93-1b.

For copies of these reports or for more information contact:

Environmental Quality Monitoring Branch
Alberta Environmental Protection
9820 - 106 St., 6th Floor
Oxbridge Place
Edmonton, Alberta
T5K 2J6
Phone (403) 427-5893

OVERVIEW

The issue of air quality and its effects on the environment has received a great deal of attention over the past decade. Alberta Environmental Protection is committed to monitoring air quality and reporting air quality information to the public. A comprehensive air quality network which monitors for 17 major air pollutants is currently operated by Alberta Environmental Protection. This network consist of 9 continuous stations, 8 intermittent stations, over 250 static stations and 13 acid precipitation stations. This report is a summary of the information collected by the air quality monitoring program in 1991.

Alberta Environmental Protection uses an air quality index to relate Good, Fair, Poor and Very Poor air quality categories to provincial and federal objectives. Outdoor concentrations of carbon monoxide, the coefficient of haze (dust and smoke), nitrogen dioxide, ozone and sulphur dioxide are used to determine this index. Continuous monitoring stations are located in Edmonton (3 stations), Calgary (3 stations), Fort Saskatchewan, Fort McMurray and Fort MacKay.

The air quality index was Good over 80% of the time at all Alberta Environmental Protection air quality monitoring stations in 1991. The frequency of Good air quality ranged from 81% in northwest Edmonton to 98% at Fort McMurray. Fair air quality was most frequent at the Edmonton northwest station (18% of the time). Poor air quality was reported less than 1% of the time at all monitoring stations. Very Poor air quality episodes occurred for five hours at the Edmonton northwest monitoring station and for two hours at the Calgary industrial monitoring location. Very Poor air quality ratings were caused by high coefficient of haze values (dust and smoke) generated by traffic movement and vehicle exhaust emissions combined with persistent stagnant air masses which limited mixing and dispersion of air pollutants.

The 1-hour regulation for ozone was exceeded three times at the Edmonton northwest station and five times at the Fort Saskatchewan monitoring station. This regulation was not exceeded at any other Alberta Environmental Protection monitoring stations. The 24-hour regulation for ozone was exceeded at all monitoring stations. Exceedances of this regulation were less frequent in downtown Edmonton and Calgary than at stations located in smaller urban centres (i.e. Fort Saskatchewan and Fort McMurray). Higher 24-hour average ozone concentrations in smaller urban centres are largely due to ozone that is present naturally in the background atmosphere. Background or rural ozone is transported into urban centres and is destroyed by nitric oxide that is predominantly emitted by automobiles. This ozone destruction mechanism explains lower 24-hour average ozone concentrations in downtown Edmonton and Calgary.

Pollutants which are predominantly emitted by motor vehicles include carbon monoxide, dust and smoke (coefficient of haze), oxides of nitrogen and some hydrocarbons. Concentrations of these pollutants were generally greater during morning and afternoon rush hours and during the fall and winter seasons at stations located close to major traffic arteries. This is due to the combination of vehicular exhaust emissions and stagnant weather conditions which inhibit the dispersion of air pollutants. The regulations for carbon monoxide were exceeded at the Edmonton central, Edmonton northwest and all Calgary stations. A downward trend in carbon monoxide concentrations is evident at all of these monitoring stations. The 1-hour regulation for nitrogen dioxide was exceeded two times at the Calgary downtown monitoring station. Nitrogen dioxide shows a downward trend at the Edmonton central monitoring unit. The guideline for the coefficient of haze was exceeded at the Edmonton northwest and Calgary industrial monitoring stations. A decrease in annual average coefficient of haze values is apparent at the Calgary residential and Fort Saskatchewan monitoring stations while a slight increase in noted at the east Edmonton station.

Carbon dioxide monitoring began in downtown Calgary in March of 1991 and at a location about 20 km west-northwest of downtown Calgary in August of 1991. Average concentrations of carbon dioxide observed at these locations were higher then those recorded at Crossfield, situated 40 km north of Calgary. Higher carbon dioxide concentrations in downtown Calgary are attributed to the combustion of fossil fuels.

High values of hydrogen sulphide and total hydrocarbons were recorded at the Edmonton east monitoring location in 1991. The 1-hour regulation for hydrogen sulphide was exceeded 59 times at this location. A total of 48 of these exceedances occurred in March and April. The frequency of exceedances declined substantially after April, following an investigation from the Pollution Control Division of Alberta Environmental Protection. The 1991 annual average total hydrocarbon concentration recorded at the Edmonton east station was 75% greater than that reported in 1990. Total hydrocarbon concentrations greater than 50 ppm (parts per million) were recorded during June, September, October and November at the Edmonton east station. Normal background total hydrocarbon concentrations are about 1.5 ppm. Elevated hydrogen sulphide and hydrocarbon values at this location were caused by fugitive emissions from industrial sources such as petroleum storage tanks in east Edmonton.

Suspended particulate and dustfall loadings exceeded the regulations or guidelines on numerous occasions at most Alberta Environmental Protection monitoring stations. The suspended particulate regulation at the Calgary industrial monitoring location was exceeded a total of 18 days. The highest frequency of exceedances of the total dustfall guidelines was recorded at Lethbridge where the residential guideline was exceeded 83% of the time and the industrial guideline was exceeded 25% of the time. The major sources of dustfall and particulates are vehicle exhaust, road dust, wind-blown soil and industrial emissions. A downward trend in annual average suspended particulate loadings is apparent at the Edmonton central, Edmonton northwest, Ellerslie and all Calgary monitoring stations. This trend is most significant at the Calgary industrial and downtown stations.

A downward trend in atmospheric lead loadings is evident at all Alberta monitoring stations based on 12 years of data. This trend is most prevalent at monitoring stations which are located close to major traffic arteries. Lower lead loadings can be attributed to a general decrease in the use of leaded gasoline during the 1980s and the suspended sale of leaded gasoline in 1990.

The most acidic precipitation was recorded in northeastern Alberta at the Fort McMurray precipitation station in 1991. The least acidic precipitation values were observed in southern Alberta at the Suffield station. A significant decrease in pH values (increase in acidity) is evident at several monitoring stations based on data collected from 1978 to 1990. This trend is likely due to better data collection and sampling techniques (i.e. less dust contained in the samples). The average pH in precipitation for the entire province from 1978 to 1990 is 5.5, which is close to that of uncontaminated precipitation.

Detailed air quality information and data are available in the reports entitled:

- "Air Quality Monitoring Report for Alberta: 1991"; and
- "Air Quality Monitoring Data Summary for Alberta: 1991".

These reports are available on request from Alberta Environmental Protection.

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ABBREVIATIONS

IQUA - index of the quality of the air

O_3 - ozone

CO - carbon monoxide

CO_2 - carbon dioxide

COH - coefficient of haze

NO_2 - nitrogen dioxide

SO_2 - sulphur dioxide

H_2S - hydrogen sulphide

THC - total hydrocarbons

NH_3 - ammonia

TSP - total suspended particulates

BaP - Benzo (a) Pyrene

Pb - lead

VCM - vinyl chloride monomer

UNITS OF MEASUREMENT

ppm - parts per million by volume

ppb - parts per billion by volume

ug/m^3 - micrograms per cubic meter

$ug/1000\ m^3$ - micrograms per 1000 cubic meters

mg SO_3 equivalent/day/100 sq cm - milligrams of SO_3 per day per 100 square centimeters

mg/100 sq cm/30 days - milligrams per 100 square centimeters per 30 days

ug water soluble fluorides/100 sq cm/ 30 days - micrograms of water soluble fluorides per 100 square centimeters per 30 days

SUMMARY OF AIR QUALITY MONITORING IN ALBERTA: 1991

INTRODUCTION

In the early 1960s, the province began air quality monitoring at one station located in downtown Edmonton. By the mid 1970s, two more stations were added in Edmonton and by the end of the 1970s three stations were established in Calgary. In addition, air quality stations were installed at Fort McMurray, Fort MacKay and Fort Saskatchewan by the early 1980s. Today, a comprehensive network of 9 continuous stations, 8 intermittent stations, over 250 static stations and 13 acid precipitation stations make up the Alberta Environmental Protection air quality monitoring program. The objectives of the air quality monitoring program are to:

- *provide data for the assessment of existing air quality relative to regulations and objectives;*
- *inform the public on the status of air quality;*
- *monitor air quality in representative urban environments to document human exposure to air pollution;*
- *report long-term trends in air quality; and*
- *undertake monitoring in special problem areas.*

Air quality is an issue that is difficult to assess unless it is put into terms of a single, easily comprehensible indicator. The *I*ndex of the *QU*ality of the *A*ir (IQUA), developed by a federal-provincial committee in 1978, has been adopted by Alberta as well as other Canadian provinces.

THE INDEX OF THE QUALITY OF THE AIR (IQUA)

The IQUA relates concentrations of five major pollutants to a common scale which may be easily interpreted by the public. This scale associates Good, Fair, Poor and Very Poor air quality categories with provincial and federal air quality objectives. Outdoor concentrations of carbon monoxide, the coefficient of haze (dust and smoke), nitrogen dioxide, ozone and sulphur dioxide are used to determine the IQUA. The IQUA is updated twice daily (8:15 a.m. and 3:15 p.m.) at Edmonton and Calgary. The index telephone number is 427-7273 in Edmonton and 250-2099 in Calgary. In addition, the IQUA is reported by MacLaren Plansearch on The Weather Network.

The IQUA is calculated each hour at all Edmonton, Calgary, Fort Saskatchewan and Fort McMurray monitoring stations. The air quality index was in the Good category over 80% of the time at all Alberta Environmental Protection monitoring stations in 1991. The frequency of Good IQUA ratings ranged from 81% at the Edmonton northwest monitoring station to 98% at the Fort McMurray monitoring station. Fair air quality index ratings were most frequent in northwest Edmonton (18%), east Edmonton (11%) and Fort Saskatchewan (11%). Poor IQUA ratings occurred most often at the Edmonton northwest and Calgary industrial (southeast Calgary) monitoring stations. The IQUA was in the Poor category less than 1% of the time at all monitoring stations. The coefficient of haze (dust and smoke) was responsible for most of the Poor IQUA readings at the Edmonton and Calgary stations. Ozone was the primary pollutant which contributed to Poor air quality ratings at Fort Saskatchewan.

IQUA rating	Frequency in Alberta	Effects
Good	almost all the time	Desirable range: no known harmful effects to soil, water, vegetation, animals, materials, visibility or human health. The long-term goal for air quality in Canada is to be in this range all the time.
Fair	occasional (typical when weather conditions inhibit pollutant dispersion)	Acceptable range: adequate protection against harmful effects to soil, water, vegetation, animals, materials, visibility and human health.
Poor	very seldom	Tolerable range: not all aspects of the environment are adequately protected from possible adverse effects. Long-term control action may be necessary, depending on the frequency, duration and circumstances of the readings.
Very Poor	very rare	Intolerable range: at this range, further deterioration of air quality and continued high readings could pose a risk to public health.

An episode consisting of Poor and Very Poor air quality readings occurred in Edmonton from the late morning of December 27 to the early morning of December 29. This episode was most severe at the Edmonton northwest monitoring station where Very Poor air quality ratings were recorded for five hours on the morning of December 28. The cause of this air quality episode was the combination of traffic movement and emissions from motor vehicles with stable weather conditions which lead to increased pollutant concentrations in the atmosphere. The major pollutant responsible for Very Poor IQUA ratings was the coefficient of haze, or dust and smoke in the atmosphere. Concentrations of pollutants such as carbon monoxide, oxides of nitrogen and hydrocarbons were also relatively high on these days.

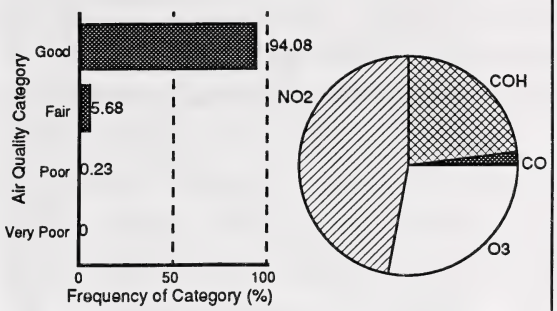
Very Poor air quality was observed on two separate occasions at the Calgary industrial monitoring station in 1991. These episodes occurred on the morning of January 11 and the morning of November 8. Dust and smoke in the atmosphere were the major contributors to the IQUA on these days. Pollutant dispersion was limited on these days due to persistent temperature inversions which would not allow pollutants to disperse rapidly.

The pollutants responsible for the IQUA ratings are largely dependent on the location of the monitoring station relative to the pollutant sources. For example, in downtown areas of Edmonton and Calgary, pollutants such as carbon monoxide, the coefficient of haze and nitrogen dioxide commonly influence the IQUA rating. In less urban locations, such as Fort McMurray and Fort Saskatchewan, ozone is often the most common pollutant.

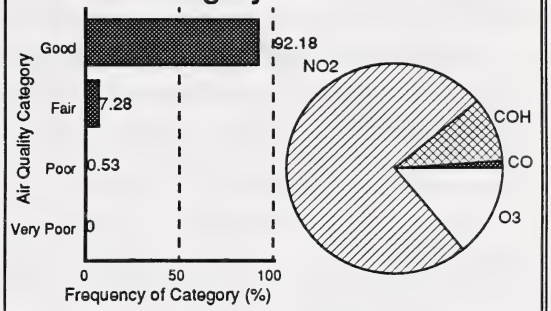
THE INDEX OF THE QUALITY OF THE AIR

Edmonton 427-7273
Calgary 250-2099

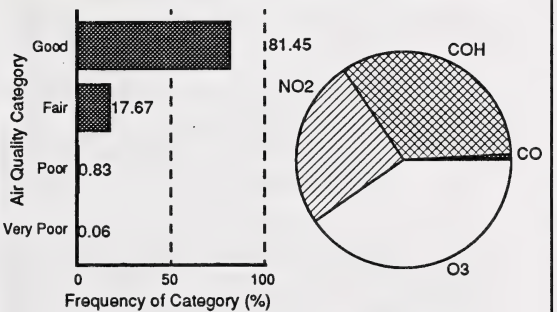
Edmonton Central



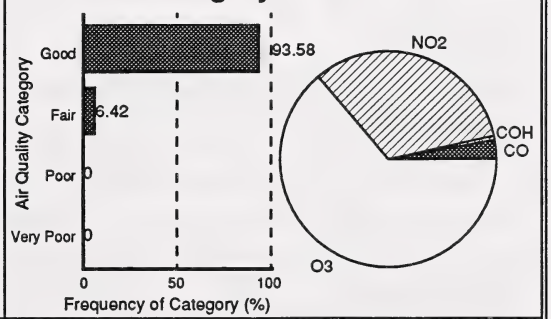
Calgary Downtown



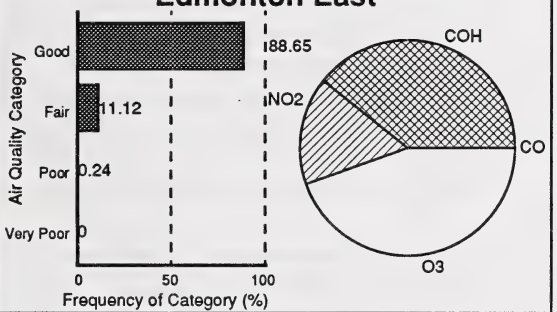
Edmonton Northwest



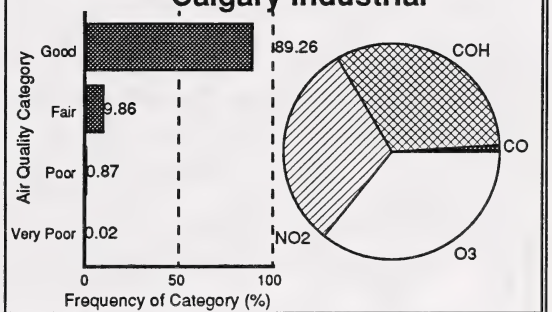
Calgary Residential



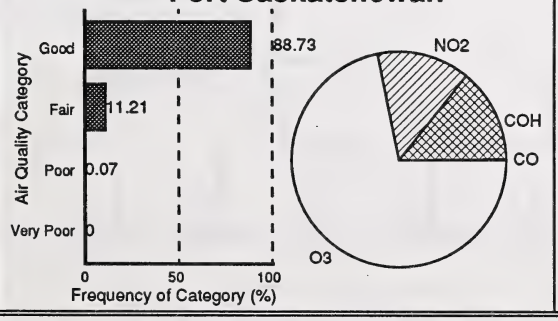
Edmonton East



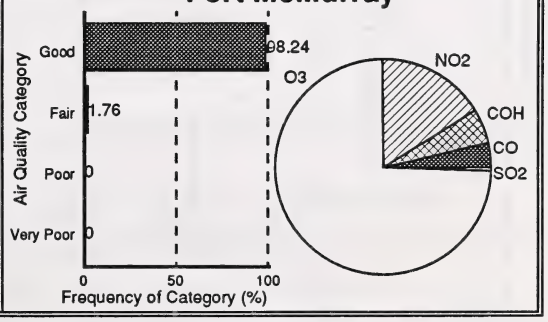
Calgary Industrial



Fort Saskatchewan



Fort McMurray



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CONTINUOUS AIR QUALITY MONITORING

Air pollutants such as ozone, carbon monoxide, carbon dioxide, the coefficient of haze, nitrogen dioxide, sulphur dioxide, hydrogen sulphide, total hydrocarbons and ammonia are monitored continuously by Alberta Environmental Protection. Concentrations of these pollutants are reported once every hour, 24 hours a day, 365 days a year.

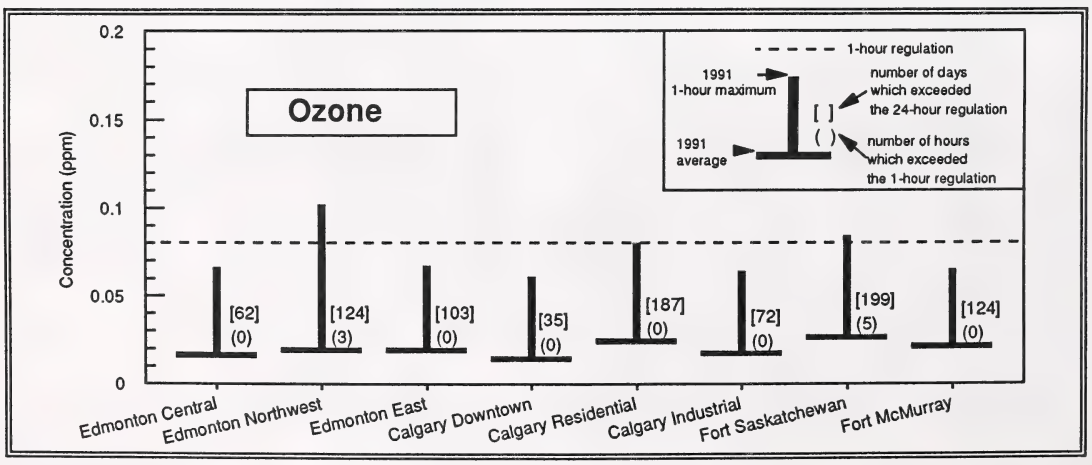
Ozone (O_3)

At normal outdoor concentrations, ozone is a colourless, odourless gas. However, ozone does have a characteristic sharp odour when at very high concentrations, such as that associated with lightning storms. Unlike many other pollutants, ozone is not emitted directly by man's activities, but is generated by a photochemical reaction between ultra-violet light from the sun with oxides of nitrogen (NO_x) and volatile organic compounds (VOCs). Residual nitrogen dioxide produced by this reaction may then be transported downwind and react with sunlight to form ozone and other photochemical pollutants. Ozone is also transported to ground level from the upper atmosphere by natural meteorological mixing processes. Ozone and ozone precursors, such as NO_x and VOCs, may also be carried from upwind sources such as urban centres and industrial complexes. A major source of VOCs in rural areas is natural emissions from trees and vegetation. In Alberta, ozone concentrations are generally higher at rural locations than at urban locations. This is due to emissions of nitric oxide from motor vehicles in urban areas which act as a mechanism for ozone destruction.

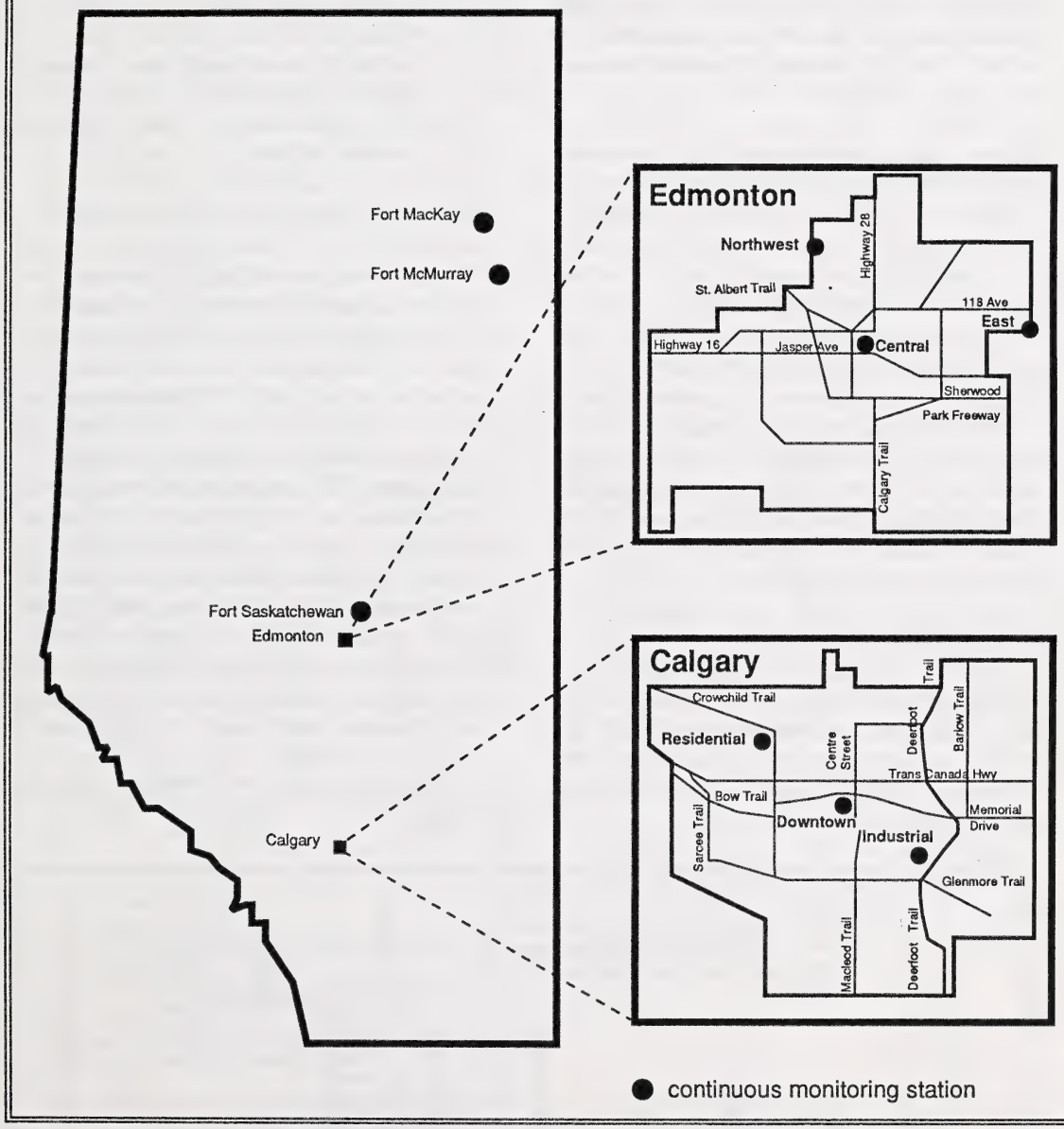
The regulations for ozone are as follows:

- *0.082 ppm as a 1-hour average concentration; and*
- *0.025 ppm as a 24-hour average concentration.*

The 1-hour regulation for ozone was exceeded three times at the Edmonton northwest monitoring station and five times at the Fort Saskatchewan station in 1991. The 24-hour regulation was exceeded frequently at all monitoring stations. The most exceedances of the 24-hour regulation were recorded at the Fort Saskatchewan and Calgary residential stations where 199 and 187 days had ozone concentrations greater



LOCATION OF CONTINUOUS AIR QUALITY MONITORING STATIONS



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than the 24-hour regulation, respectively. Exceedances of the 24-hour regulation were recorded most frequently in the months of April, May and June at all monitoring stations. It is important to note that exceedances of the 24-hour regulation for ozone are the result of natural ozone generating processes.

Ozone concentrations reach a maximum during the spring and summer months at all monitoring stations in Alberta. During the late spring and summer, ozone production in the lower atmosphere is at a maximum due to a peak in incoming sunlight combined with stagnant weather conditions which may cause reactive pollutants to remain in the region for a prolonged period of time. Transport of ozone from rural areas may occasionally be the cause of elevated ozone levels in Edmonton and Calgary. During the early spring, high daily average ozone values may be influenced by transport of ozone from the upper atmosphere.

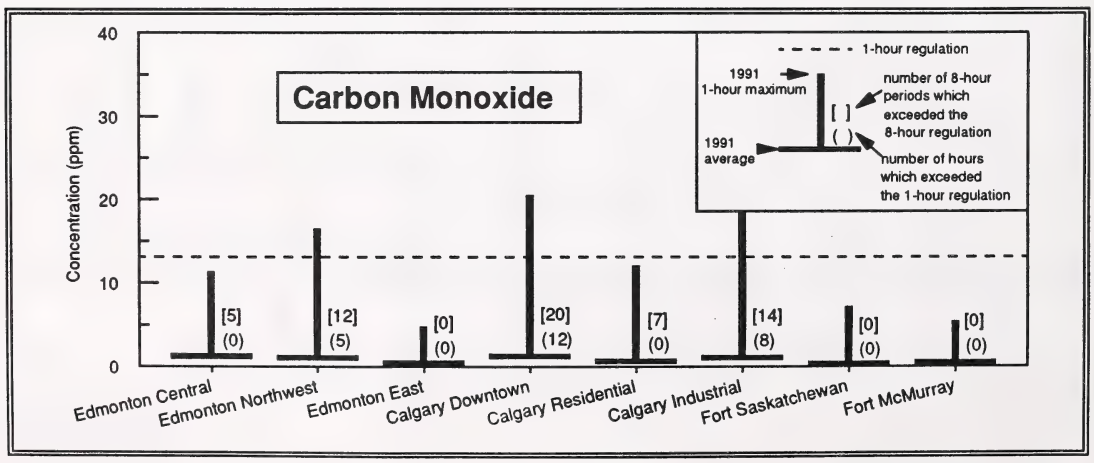
Carbon Monoxide (CO)

Carbon monoxide is a colourless, odourless gas emitted into the atmosphere primarily by motor vehicles. Minor sources include fireplaces, industry, aircraft and natural gas combustion.

In regulating carbon monoxide, Alberta has adopted Environment Canada's most rigorous ambient air quality regulations. Maximum permissible carbon monoxide concentrations are:

- *13.0 ppm as a 1-hour average concentration; and*
- *5.0 ppm as an 8-hour average concentration.*

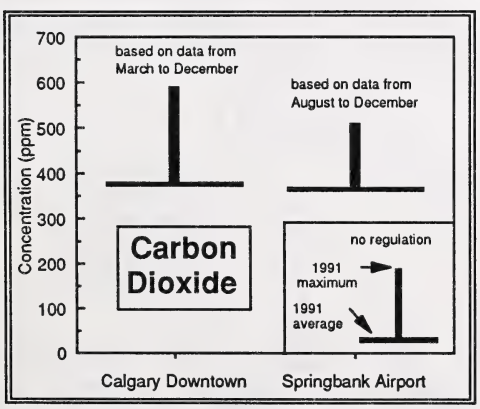
Ambient carbon monoxide concentrations exceeded the 1-hour regulation at the Edmonton northwest, Calgary downtown and Calgary industrial monitoring stations. The 8-hour regulation was exceeded at the Edmonton central and northwest stations as well as at all the Calgary monitoring stations. All exceedances of the 1-hour and 8-hour regulations occurred in the late fall and winter. The major factor which causes exceedances of the regulation for carbon monoxide is the combination of vehicle exhaust emissions with stagnant weather conditions, such as inversions, which do not allow pollutants to disperse rapidly. Concentrations of carbon monoxide were generally at a maximum during the morning and afternoon rush hours. This pattern is especially visible at the downtown monitoring locations in Edmonton and Calgary.



Carbon Dioxide (CO_2)

Carbon dioxide is a colourless, odourless, non-toxic gas that is produced by man through the combustion of fossil fuels. Major natural sources of carbon dioxide include the respiration processes of micro-organisms and plants. Carbon dioxide emissions are responsible for over half of the greenhouse gases emitted by man. At the present time, regulations do not exist for ambient levels of carbon dioxide.

Monitoring of carbon dioxide commenced in downtown Calgary in March of 1991. A second temporary monitoring station was added at the Springbank Airport, approximately 20 km west-northwest of downtown Calgary in August of 1991. Average carbon dioxide concentrations at the Calgary downtown and Springbank stations were 376 and 366 ppm, respectively. These average values are higher than those observed from 1985 to 1987 at Crossfield (40 km north of Calgary) where values of 345 to 348 ppm were recorded. Higher carbon dioxide concentrations in downtown Calgary are due to fossil fuel combustion sources.

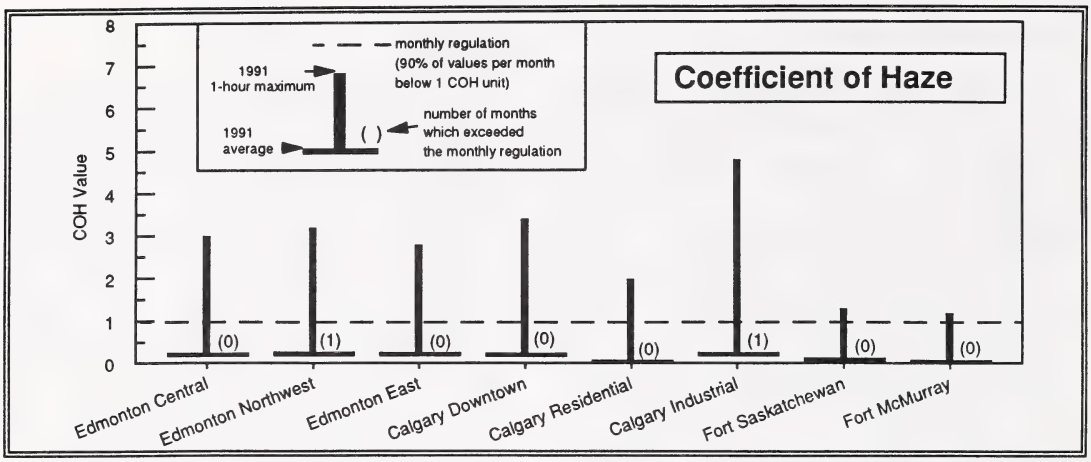


Coefficient of Haze (COH)

The coefficient of haze is a measurement of the degree of dust and smoke in the atmosphere. Dust and smoke may originate from road dust, wind-blown soil, industrial sources, automobile emissions, agricultural activities, open burning and various other sources. The guideline for the coefficient of haze, which is based on visibility, established by Alberta Environmental Protection is that:

- *90% of the readings per month shall be less than 1.0 COH unit.*

The guideline for the coefficient of haze was exceeded in December at the Edmonton northwest monitoring station and in November at the Calgary industrial station. High dust and smoke concentrations lead to the occurrence of Poor and Very Poor air quality episodes in December at the Edmonton northwest station in January and November at the Calgary industrial monitoring station. The highest coefficient of haze values were generally observed in the fall, winter and early spring seasons at all monitoring stations. Coefficient of haze values were much higher at urban stations in Edmonton and Calgary than at the more rural Fort Saskatchewan and Fort McMurray stations. Higher values were also apparent during the morning and afternoon rush hours. This is indicative of vehicular movement which contributes to dust and smoke in the atmosphere.

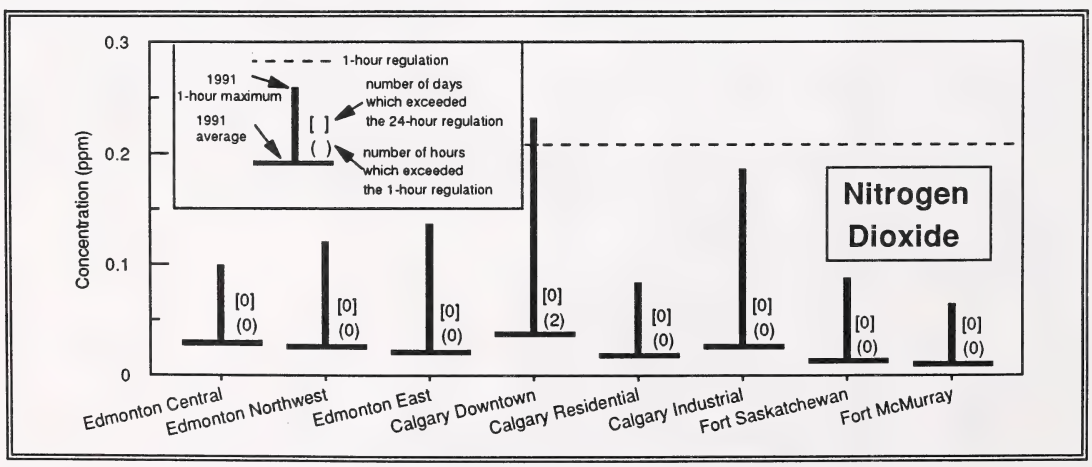


Nitrogen Dioxide (NO_2)

Nitrogen dioxide is a reddish-brown gas with a pungent odour which is partially responsible for the brownish discolouration of the lower atmosphere in urban locations. In Alberta, about 38% of nitrogen dioxide emissions are produced by the oil and gas industry while 29% are due to transportation (aircraft and vehicles) and 16% due to power plants. Smaller sources of nitrogen dioxide include natural gas combustion, heating fuel combustion, and forest fires. The largest urban source of nitrogen dioxide is emissions from motor vehicles. Regulations for nitrogen dioxide are based on human health effects. The regulations are:

- *0.21 ppm as a 1-hour average concentration;*
- *0.11 ppm as a 24-hour average concentration; and*
- *0.03 ppm as an annual average concentration.*

The 1-hour regulation for nitrogen dioxide was exceeded two times at the Calgary downtown monitoring station in 1991. These exceedances were recorded in January. The annual average regulation was also



exceeded at the Calgary downtown station. The highest nitrogen dioxide concentrations were generally observed at the Calgary downtown, Edmonton central, Edmonton northwest and Calgary industrial stations. Sources of nitrogen dioxide in these areas are emissions from vehicle exhaust and heating fuel consumption.

Maximum nitrogen dioxide concentrations are observed in the winter. This is likely due to vehicular exhaust emissions combined with persistent stable weather conditions. As with carbon monoxide and the coefficient of haze, nitrogen dioxide peaks are evident during the morning and afternoon traffic rush hours.

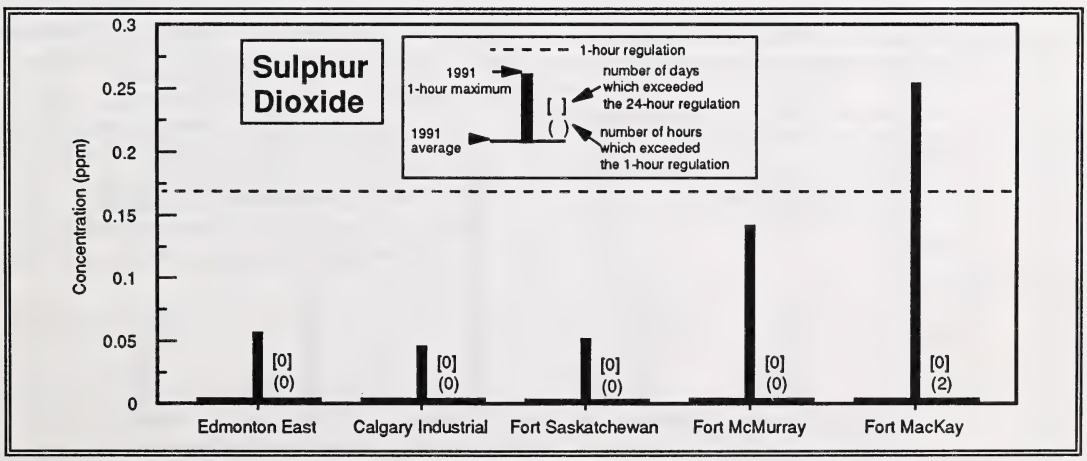
Sulphur Dioxide (SO_2)

Sulphur dioxide is a colourless gas with a pungent odour. In Alberta, it is estimated that 38% of sulphur dioxide emissions are emitted by sulphur extraction plants while oil sands and power plants produce about 29% and 16% of sulphur dioxide emissions, respectively. Other sources include gas plant flares, oil refineries, pulp and paper mills and fertilizer plants.

Alberta Environmental Protection has adopted Environment Canada's most rigorous regulations for sulphur dioxide. The following regulations are based on prevention of effects to vegetation:

- *0.17 ppm as a 1-hour average concentration;*
- *0.06 ppm as a 24-hour average concentration; and*
- *0.01 ppm as an annual average concentration.*

The 1-hour regulation for sulphur dioxide was exceeded two times at the Fort MacKay monitoring station in 1991. Exceedances of the regulations were not recorded at any other monitoring stations. The maximum 1-hour average concentration at Fort MacKay was 0.254 ppm. This value is 1.5 times the regulation for 1-hour average concentrations of sulphur dioxide. Elevated sulphur dioxide readings at this location were due to emissions from the oil sands processing facilities.



Hydrogen Sulphide (H_2S)

Hydrogen sulphide is a colourless gas with a rotten egg odour. Industrial sources include petroleum refineries, natural gas plants, petrochemical plants, coke oven plants, and pulp and paper plants which use the kraft pulping process. Natural sources of hydrogen sulphide include sulphur hot springs, sloughs, swamps and lakes.

Regulations for hydrogen sulphide are based on the odour threshold; however, many individuals can smell hydrogen sulphide at levels lower than the ambient regulation. The regulations for hydrogen sulphide in Alberta are:

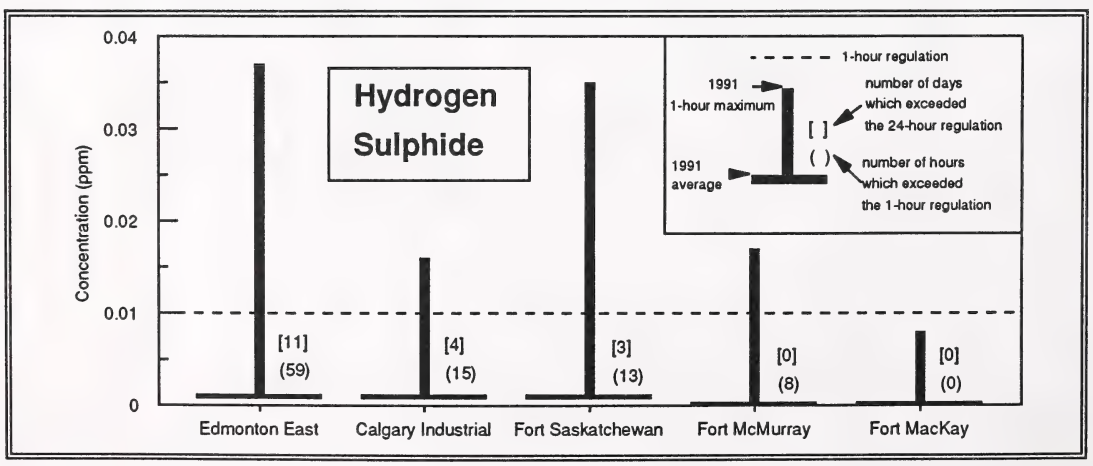
- *0.010 ppm as a 1-hour average concentration; and*
- *0.003 ppm as a 24-hour average concentration.*

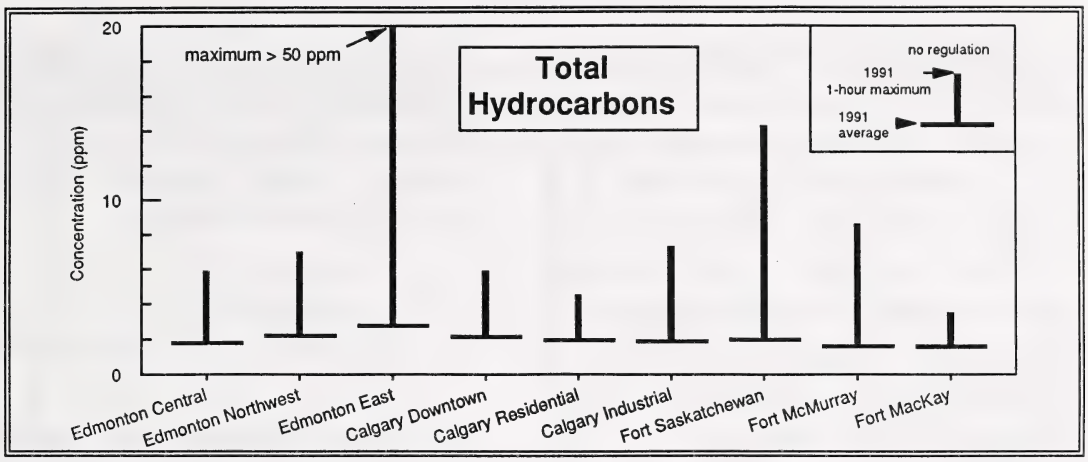
Frequent exceedances of the 1-hour regulation for hydrogen sulphide were observed at the Edmonton east monitoring station in 1991. The highest frequency of exceedances occurred in March (32 hours) and April 16 hours). The frequency of exceedances of the 1-hour regulation dropped off after April, following an investigation by the Pollution Control Division of Alberta Environmental Protection. The 1-hour regulation was also exceeded at the Calgary industrial, Fort Saskatchewan and Fort McMurray monitoring stations. Exceedances at these locations were probably caused by fugitive emissions from industrial facilities. The 24-hour regulation for hydrogen sulphide was exceeded at the Edmonton east, Calgary industrial and Fort Saskatchewan monitoring stations. A total of 11 days exceeded this regulation at the Edmonton east station.

Total Hydrocarbons (THC)

The term "total hydrocarbons" refers to methane and reactive hydrocarbons. Reactive hydrocarbons (or volatile organic compounds) may react with sunlight to form ozone. Sources of hydrocarbons include vegetation, vehicular emissions, gasoline marketing and storage tanks, petroleum and chemical industries, drycleaning, fireplaces, natural gas combustion and aircraft traffic.

Frequent high total hydrocarbon concentrations were recorded at the Edmonton east monitoring station in 1991.





The annual average concentration was 75% higher in 1991 than in 1990. Hydrocarbon concentrations exceeded 50 ppm in June, September, October and November at this location. The highest total hydrocarbon concentration observed at a station other than the Edmonton east station was 14.3 ppm which occurred at the Fort Saskatchewan monitoring station. Fugitive emissions from petroleum storage tanks are the major sources of hydrocarbons in east Edmonton. Natural background concentrations of total hydrocarbons are about 1.5 ppm.

Hydrocarbon concentrations were the highest in the winter months at monitoring stations which are located close to major traffic arteries. In downtown Edmonton and Calgary, maximum hydrocarbon values were observed during the morning and afternoon rush hours. This shows that vehicles are the major source of hydrocarbons at urban locations. No regulations exist for ambient total hydrocarbon concentrations.

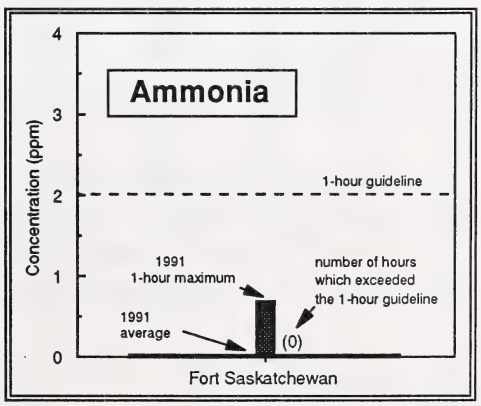
Ammonia (NH_3)

Ammonia is a colourless gas with a pungent odour. Ammonia is emitted into the atmosphere through natural sources such as animal decay and animal excretions, and man-made sources such as the fertilizer industry.

The guideline for maximum permissible ammonia concentrations is:

- *2.0 ppm as a 1-hour average concentration.*

Ammonia is monitored at Fort Saskatchewan because of its proximity to the fertilizer industry. The overall maximum recorded ammonia concentration at the Fort Saskatchewan station was 0.7 ppm. This value is 35% of the guideline for ammonia. Ammonia concentrations were below the limit of detection over 90% of the time from March to October in Fort Saskatchewan.



INTERMITTENT AIR QUALITY MONITORING

Intermittent air quality monitoring refers to air pollutants which are monitored as a 24-hour accumulated loading, once every sixth day, according to the National Air Pollution Surveillance (NAPS) monitoring scheme. Suspended particulates, Benzo (a) Pyrene and lead are monitored according to this system. Vinyl chloride monomer is also monitored on an intermittent basis in the Fort Saskatchewan region.

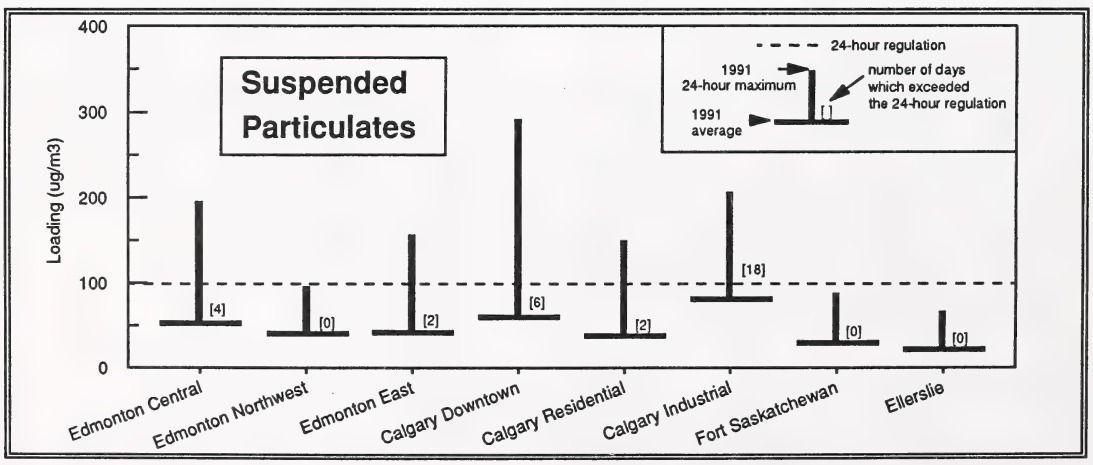
Total Suspended Particulates (TSP)

Suspended particulates are particles which range from about 0.001 to 500 microns in diameter (a human hair is about 100 microns in diameter) and, depending on their density, may remain suspended in the air for an indefinite period of time. Suspended particulates may originate from soil, road and agricultural dust; smoke from forest fires and recreational fires; vehicular exhaust emissions; and industrial sources.

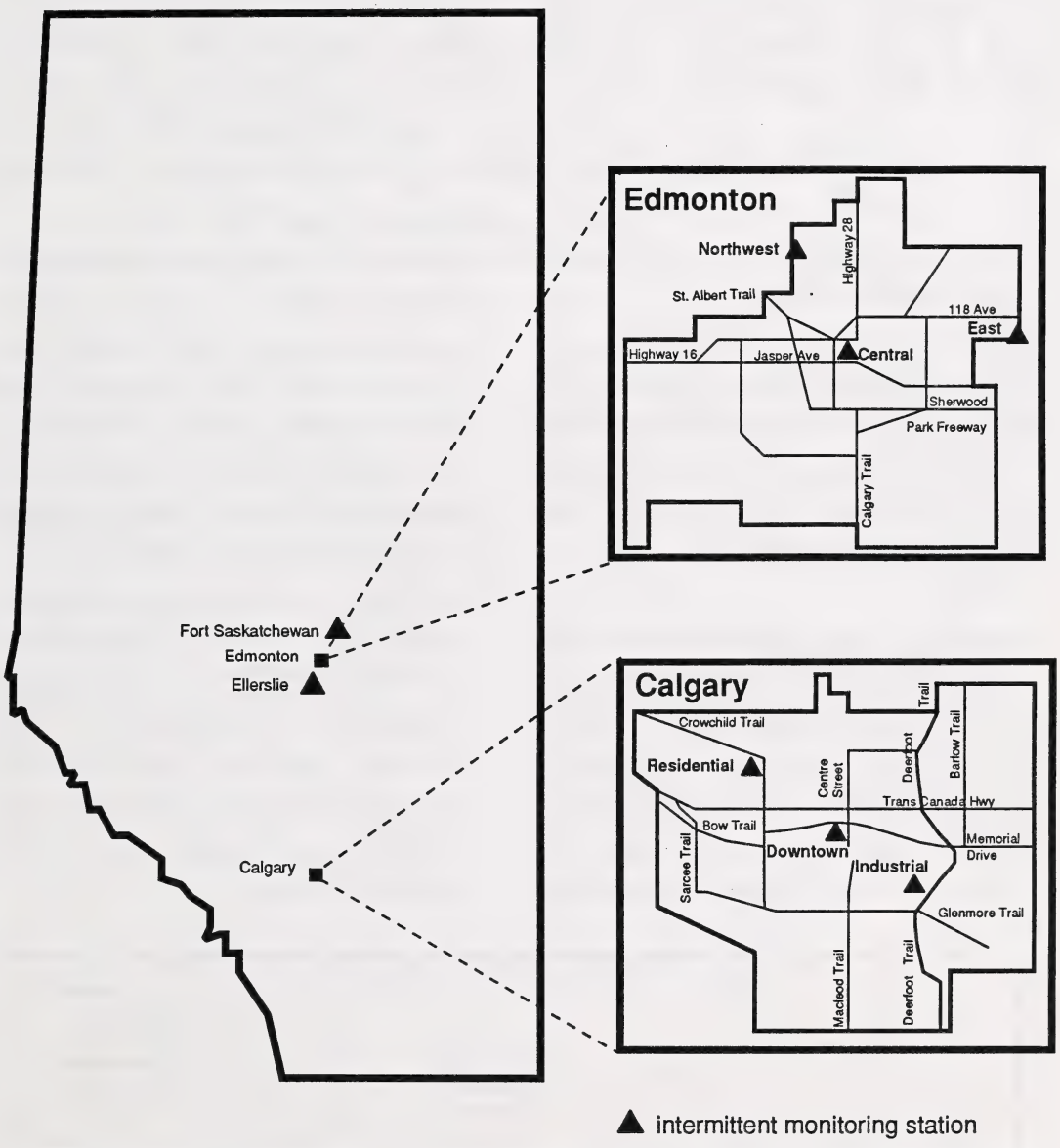
The regulations for total suspended particulates are based on nuisance effects and visibility reduction. Alberta Environmental Protection has adopted the following federal standards for total suspended particulate loadings:

- *100 ug/m^3 as a 24-hour total loading; and*
- *60 ug/m^3 as an annual average loading.*

The 24-hour regulation for suspended particulates was exceeded at the Edmonton central, Edmonton east and all Calgary monitoring stations. The highest number of exceedances was observed at the Calgary industrial station where 18 days exceeded the 24-hour regulation. The annual average regulation was also exceeded at the Calgary industrial monitoring station. Exceedances of the regulations at the Calgary industrial and Edmonton east monitoring stations were due to the combination of vehicular traffic and industrial emissions. The primary source of suspended particles in downtown Edmonton and Calgary was vehicular traffic.



LOCATION OF INTERMITTENT AIR QUALITY MONITORING STATIONS



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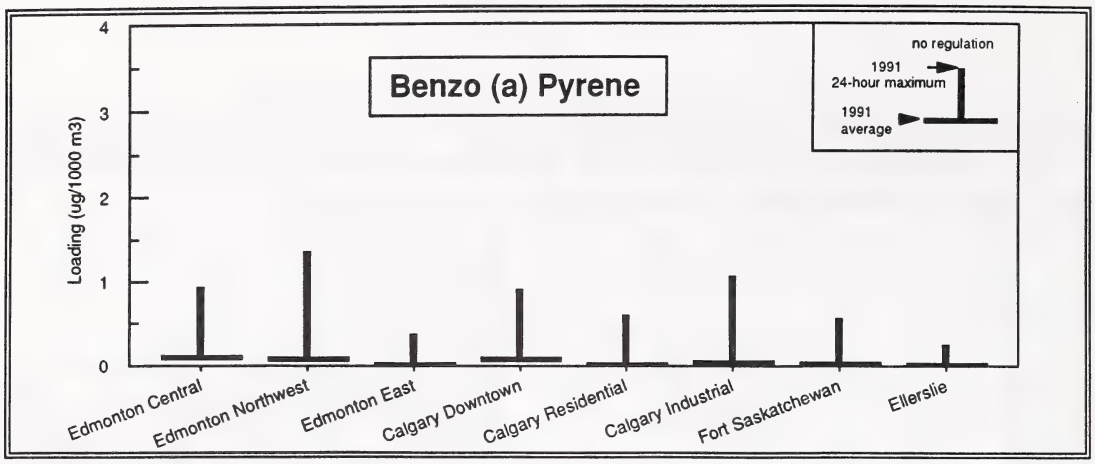


Benzo (a) Pyrene (BaP)

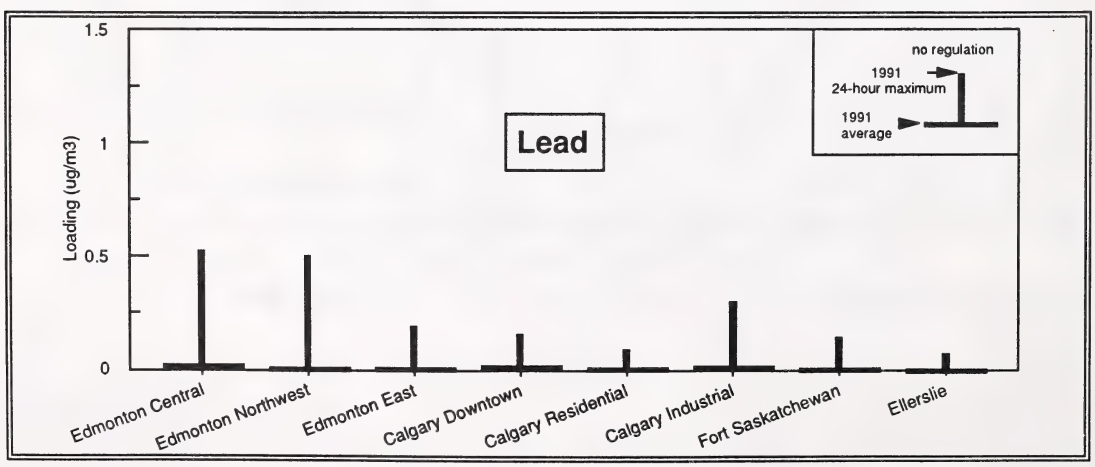
Benzo (a) Pyrene is a polycyclic aromatic hydrocarbon (PAH) that is contained in all types of soot and smoke. Vehicular exhaust, and smoke from industrial and recreational emissions are the most common sources of Benzo (a) Pyrene. No air quality regulations currently exist in Alberta for Benzo (a) Pyrene.

Benzo (a) Pyrene loadings were generally greater at monitoring stations located close to major traffic arteries. Substantially higher Benzo (a) Pyrene values were recorded at Edmonton central, Edmonton northwest and Calgary downtown stations than at smaller centres such as Fort Saskatchewan and Ellerslie. The major source of Benzo (a) Pyrene at these locations is vehicular emissions.

Lead (Pb)

Lead is emitted into the atmosphere primarily as a result of burning leaded gasoline in motor vehicles. Other sources of atmospheric lead include iron and steel manufacturing, solid waste incineration and battery manufacturing. There are no ambient regulations for lead in Alberta.

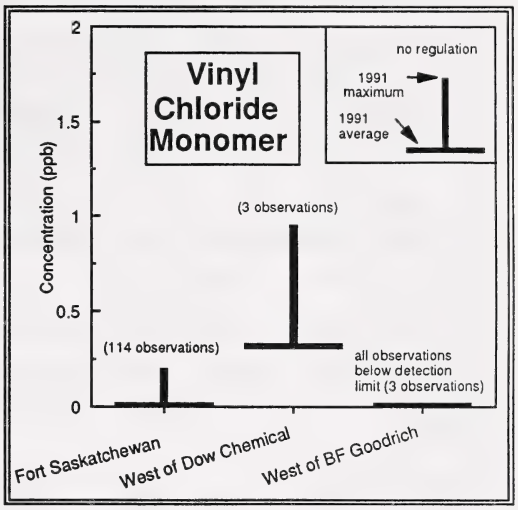
The highest lead loadings were observed at the Edmonton central and Calgary industrial monitoring locations. An annual average lead value of 0.05 ug/m^3 (micrograms per cubic meter) was recorded at each of these locations. This value is about one-third of the maximum annual average lead loading recorded in 1990. Lead loadings were generally higher at stations located close to major traffic arteries.



Vinyl Chloride Monomer (VCM)

Vinyl chloride monomer is a colourless gas with a faint sweet odour. Vinyl chloride monomer is emitted into the atmosphere during the manufacturing of clothing, building and construction materials, home furnishings, and packaging for toys and plastics.

Annual average vinyl chloride monomer concentrations were 0.000 ppb near the BF Goodrich plant, 0.003 ppb at the Fort Saskatchewan station and 0.317 ppb near the Dow Chemical plant. Annual average values are based on only three observations at the locations near the BF Goodrich and Dow Chemical plants compared to 114 observations at the Fort Saskatchewan monitoring station. Vinyl chloride monomer concentrations were below the limit of detection 97% of the time based on data collected in 1991.



STATIC AIR QUALITY MONITORING

Alberta Environmental Protection conducts air quality monitoring, on a static basis, at approximately 52 networks throughout Alberta. Each network consists of at least one monitoring station. Static monitoring is the measurement of total accumulated loadings of pollutants on a one- and three-month schedule. This type of air quality monitoring is useful as a simple, inexpensive indicator of trends. Parameters monitored on a static basis include total sulphation, hydrogen sulphide, dustfall, calcium and fluorides.

Total Sulphation

Total sulphation is the measurement of sulphur-containing compounds which exist in the atmosphere. Sulphur recovery gas plants, coal-burning power plants and petroleum refining plants are common sources of these gases.

The guideline for total sulphation loading in Alberta is:

- *0.50 mg SO_3 equivalent/day/ 100 sq cm.*

The guideline for total sulphation was not exceeded in 1991. The highest annual average total sulphation values were recorded at the Coleman, Nevis and Waterton monitoring networks. An overall maximum total sulphation loading of 0.284 mg/day/100 sq cm was recorded at the Waterton network.

Hydrogen Sulphide

Hydrogen sulphide is present in the atmosphere from natural sources such as coal, natural gas, oil, sulphur hot springs, sloughs, swamps and lakes. Industrial sources of hydrogen sulphide include petroleum refining plants, natural gas plants, petrochemical complexes, coke oven plants, pulp and paper plants employing the kraft pulping process, and petroleum and gas gathering fields.

The guideline for hydrogen sulphide loading in Alberta is:

- *0.10 mg SO_3 equivalent/day/ 100 sq cm.*

Exceedances of the guideline for hydrogen sulphide did not occur at any static monitoring networks in 1991. The highest annual average hydrogen sulphide loadings were observed at the Nevis, Sherwood Park and Ram River monitoring networks. The maximum hydrogen sulphide loading was recorded at the Fort McMurray network where a value of 0.045 mg/day/100 sq cm was recorded.

Total Dustfall

Dustfall is particulate matter which is too heavy to remain suspended in the atmosphere indefinitely. Sources of dustfall include wind-blown soil, road dust, dust generated by agricultural activities, ash from forest fires and recreational fires, and flyash from industrial sources.

The Alberta Environmental Protection guidelines for total dustfall loadings are:

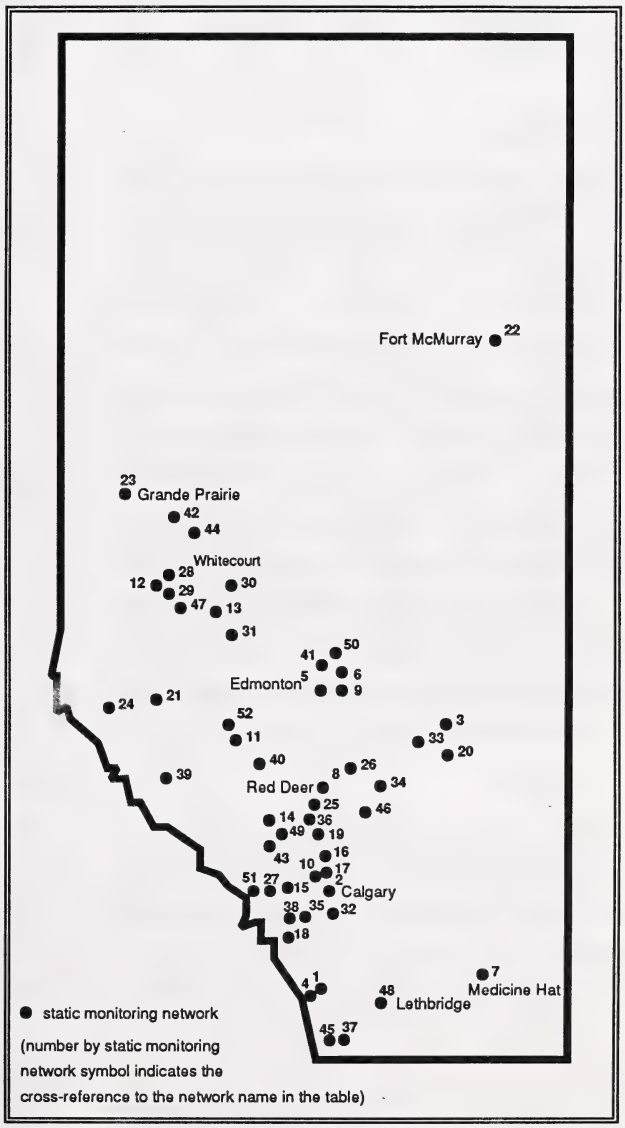
- *53 mg/100 sq cm/30 days in residential and recreational areas;*
- *158 mg/100 sq cm/30 days in commercial and industrial areas;*

LOCATION OF STATIC AIR QUALITY MONITORING NETWORKS

Map Location	Network Location
1	Blairmore
2	Calgary
3	Camrose
4	Coleman
5	Edmonton
6	Fort Saskatchewan
7	Medicine Hat
8	Red Deer
9	Sherwood Park
10	Balzac
11	Buck Lake
12	Bigstone
13	Blue Ridge
14	Caroline
16	Carstairs
15	Cochrane
17	Crossfield
18	Diamond Valley
19	Didsbury
20	Edburg
21	Edson
22	Fort McMurray
23	Grande Prairie
24	Hinton
25	Innisfail
26	Joffre
27	Jumping Pound
28	Kaybob
29	Kaybob (south)
30	Lone Pine Creek
31	Mayerthorpe
32	Mazeppa
33	New Norway
34	Nevis
35	Okotoks
36	Olds
37	Pincher Creek
38	Quirk Creek
39	Ram River
40	Rimbey
41	St. Albert
42	Simonette
43	Sundre
44	Valleyview
45	Waterton

Map Location	Network Location
46	Wimborne
47	Windfall
48	Lethbridge
49	Raven Brood

Map Location	Network Location
50	Redwater
51	Exshaw
52	Drayton Valley



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Total dustfall loadings exceeded Alberta Environmental Protection guidelines for residential regions at most networks where total dustfall is monitored. Guidelines for industrial regions were exceeded at six of these networks. The highest frequency of exceedances of the residential and industrial guidelines for dustfall occurred at the Lethbridge network where these guidelines were exceeded 83 and 25% of the time, respectively.

Calcium

Calcium emanates from natural sources such as wind-blown soil and road dust. Man-made sources of calcium in dustfall include cement, iron, steel and wood processing. There are no regulations or guidelines for atmospheric loadings of calcium in Alberta.

The highest annual average calcium loading recorded in 1991 was recorded at the Exshaw network. An annual average loading of 5.0 mg/100 sq cm/30 days (milligrams per 100 square centimeters per 30 days) was reported at this location. This value is over two times the calcium loadings recorded in the Edmonton area. Relatively high calcium loadings in the Exshaw region may be attributed to cement manufacturing activities in the area.

Fluorides

Fluorides are emitted into the atmosphere through processes such as coal combustion and the processing of phosphate bearing rock.

The Alberta Environmental Protection guideline for fluoride loading is:

- *40.0 ug water soluble fluorides/100 sq cm/30 days*

Fluoride loadings were the highest at the Redwater monitoring network with an annual average loading of 3.3 ug/100 sq cm/30 days (micrograms per 100 square centimeters per 30 days). A maximum fluoride loading of 5.9 ug/100 sq cm/30 days was recorded at the Redwater network. This value is 15% of the guideline for fluorides.

ACID PRECIPITATION MONITORING

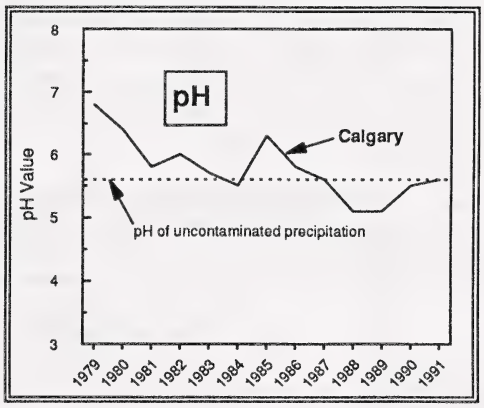
Rain and snow samples were collected, as an accumulation over a one-month period, at 13 locations in the province by Alberta Environmental Protection in 1991. Chemical analysis was conducted on these samples to obtain pH as well as other ions contained in precipitation. Target loadings for acid precipitation are currently being developed by Alberta Environmental Protection.

pH

In 1991, the most acidic (lowest pH) precipitation was recorded at the Fort McMurray precipitation monitoring station where a pH value of 4.9 was observed. Relatively low annual average pH values were also measured at Beaverlodge, Cold Lake, Edmonton, Fort Chipewyan and Kananaskis (pH of 5.2 or less). The Calgary, Drayton Valley and Suffield precipitation stations recorded annual average pH values close to that of uncontaminated precipitation (pH of 5.6). Annual average pH values higher than 5.6 were not recorded at any monitoring stations in 1991.

Based on an analysis of precipitation samples collected from 1978 to 1990, average pH values ranged from 5.0 at Fort Chipewyan to 6.1 at High Prairie. Beaverlodge, Cold Lake, Fort McMurray, and Kananaskis recorded average pH values of 5.2 or less for this period. The average pH of precipitation on a province wide basis was 5.5, close to that of uncontaminated precipitation.

A significant decrease in pH values is evident at several monitoring sites. This decrease is most apparent at the Calgary precipitation station. Lower pH values (or increased acidity) may be caused by: improved sampling techniques (i.e. less wind blown dust in the sample); increased emissions of oxides of nitrogen and sulphur dioxide in the vicinity of the station; or a change in the location of the monitoring site.



Anions (sulphate, nitrate, chloride, phosphate)

Anions in precipitation may result from emissions into the atmosphere from coal-fired power plants, oil refineries, gas plants, oil sands plants, pulp and paper plants, fertilizer plants, vehicular emissions and agricultural activities. Alberta Environmental Protection does not have regulations for anions in precipitation.

A maximum observed wet sulphate deposition rate of 6.5 kg/ha/yr (kilograms per hectare per year) was recorded at Drayton Valley. A relatively high wet sulphate value of 6.3 kg/ha/yr was measured at Red Deer. These values are substantially lower than the eastern Canada objective of 20 kg/ha/yr.

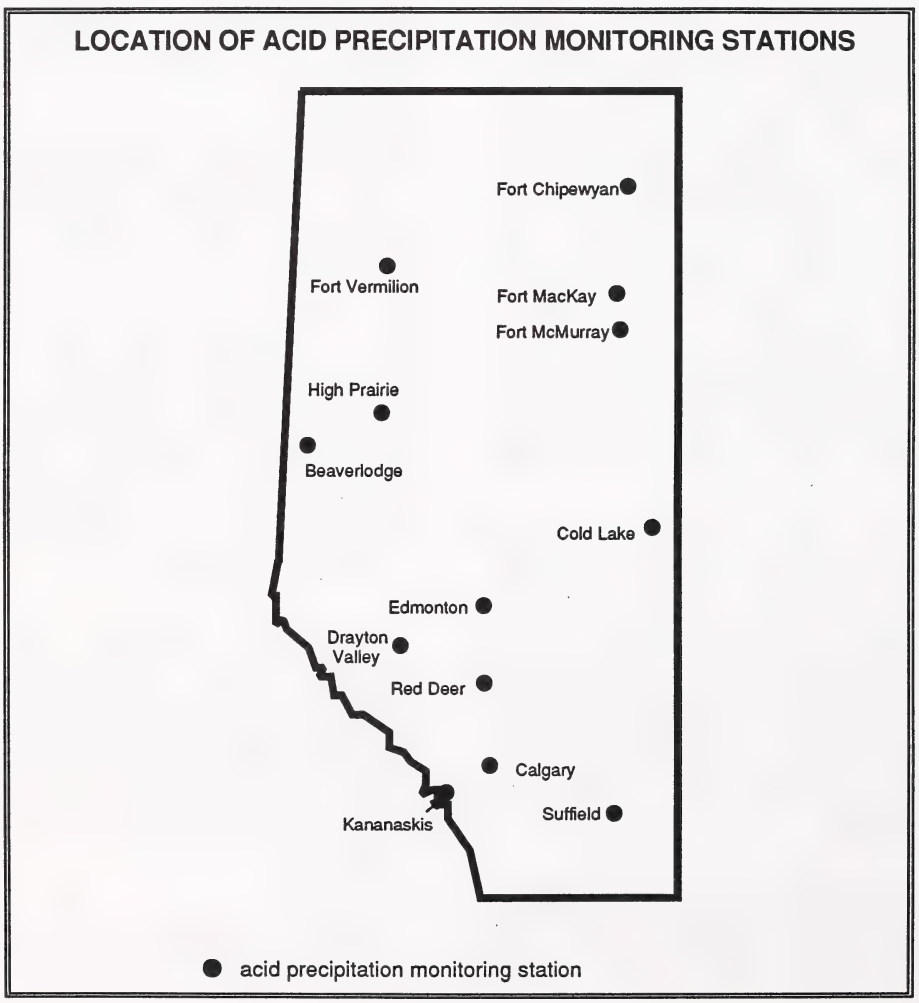
Maximum wet nitrate deposition rates were observed at Red Deer (4.8 kg/ha/yr) and

Suffield (4.6 kg/ha/yr). The highest wet chloride deposition rate was observed at Fort Vermilion. Wet phosphate deposition was relatively low at all monitoring stations.

Cations (calcium, ammonium, sodium, magnesium, potassium)

Cations may originate from industrial sources such as iron and steel manufacturing, and wood processing, or natural sources such as wind-blown soil and dust. There are currently no regulations for cations in precipitation in Alberta.

Wet calcium deposition was a maximum at Calgary with a value of 2.5 kg/ha/yr. Maximum wet ammonium deposition occurred at Drayton Valley and Red Deer where a value of 2.5 kg/ha/yr was recorded at both stations. Wet sodium deposition rates were highest at Fort Vermilion and Suffield (0.5 kg/ha/yr) while wet magnesium deposition reached a maximum at Calgary with a value of 0.7 kg/ha/yr. Maximum potassium wet deposition rates were recorded at Drayton Valley, High Prairie and Suffield where a value of 0.4 kg/ha/yr was measured.



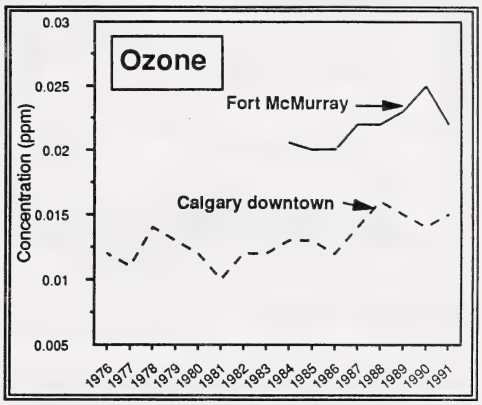
AIR QUALITY TRENDS

The long-term trend of air pollution levels is an important indicator of changes in air quality. Approximately 16 years of data are available for ozone, carbon monoxide, the coefficient of haze, nitrogen dioxide and total hydrocarbons. Twelve years of suspended particulate and lead data are available while nine years of Benzo (a) Pyrene data are available at most stations. Annual average concentrations for ammonia, hydrogen sulphide and sulphur dioxide are not high enough to resolve significant trends. Not enough data is available for carbon dioxide to determine annual average trends.

Ozone

Ozone is formed in the lower atmosphere through the reaction of sunlight with oxides of nitrogen and volatile organic compounds (VOCs). The transport of ozone from the upper atmosphere to ground level may also be an important contributor to ozone levels in the lower atmosphere. At urban locations in Alberta, ozone is often destroyed by nitric oxide emitted by automobiles.

A slight upward trend in annual average ozone concentrations is evident from data collected at the Calgary downtown and Fort McMurray monitoring stations. However, the annual average ozone concentration at Fort McMurray in 1991 was lower than that recorded in 1990. These trends may be caused by a number of contributing factors including: (1) increased concentrations of oxides of nitrogen and hydrocarbons which react with sunlight at warm temperatures to form ozone; (2) increased transport of ozone from the upper atmosphere to ground level; or (3) decreased levels of nitric oxide from motor vehicles at these locations. The portion that each of these factors contribute to ozone concentrations cannot be directly determined. Significant trends are not apparent at any other monitoring stations.

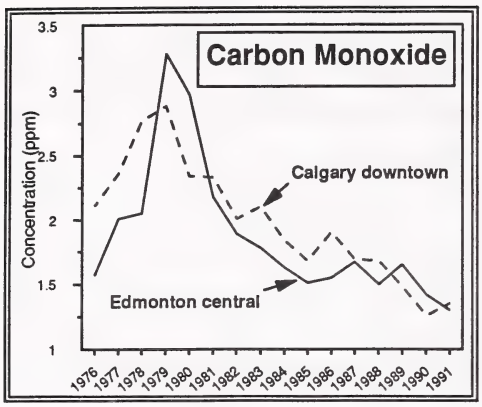


Carbon Monoxide

The major source of carbon monoxide in urban areas is vehicular emissions. Other sources include industrial emissions, aircraft emissions, fireplaces and natural gas combustion.

Based on annual average concentrations, lower carbon monoxide concentrations are evident at all monitoring stations located close to areas of high vehicular traffic. These locations include the Edmonton central, Edmonton northwest, and all Calgary monitoring stations. Lower carbon monoxide concentrations at these stations can be attributed to more efficient automobile engines and emission control devices.

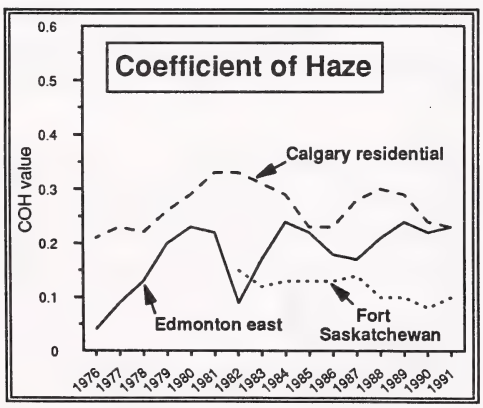
A peak in annual average carbon monoxide concentrations was evident in 1979 at most monitoring stations. This peak may reflect the boom in the economy which occurred in the late 1970s (i.e. more building construction and an increase in vehicular activity).



Coefficient of Haze

The coefficient of haze is a measurement of dust and smoke resulting from sources such as road dust, wind-blown soil, industrial emissions, automobiles, agricultural activities, open burning and fireplaces.

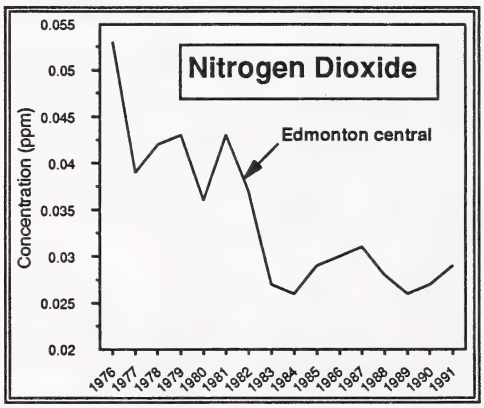
A small decrease in annual average coefficient of haze values is evident at the Calgary residential and Fort Saskatchewan monitoring stations. This decrease may be associated with cleaner streets in the vicinity of these stations. A slight increase in annual average coefficient of haze values is apparent at the Edmonton east monitoring station. This trend may be due to the combination of a greater traffic density in east Edmonton and increased industrial emissions in the region.



Nitrogen Dioxide

Major sources of nitrogen dioxide include motor vehicle emissions, aircraft emissions, the oil and gas industry, power plants, natural gas combustion and heating fuel combustion.

Nitrogen dioxide shows a significant downward trend, based on 16 years of data, at the Edmonton central monitoring station. Lower concentrations in downtown Edmonton may be due to decreased emissions of oxides of nitrogen from motor vehicles as well as decreased consumption of heating fuel. This trend was most pronounced from 1981 to 1983. Annual average nitrogen dioxide concentrations show little variability after 1983. Nitrogen dioxide levels do not show a trend at other stations.

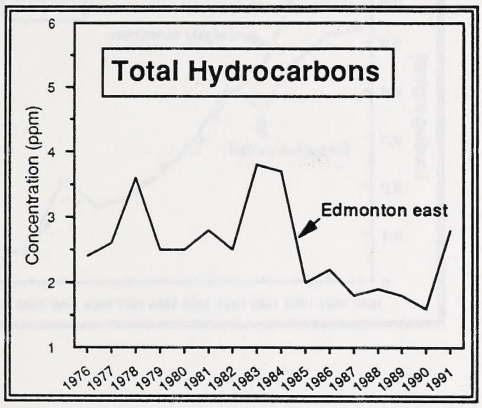


Total Hydrocarbons

Hydrocarbons may be emitted from a variety of sources. Some of these sources are vehicular emissions, the petroleum and chemical industries, and vegetation.

Prior to 1991, a decrease in annual average hydrocarbon concentrations was detected at the Edmonton east monitoring station. In 1991, the total hydrocarbon concentrations at this location increased by 75%. This

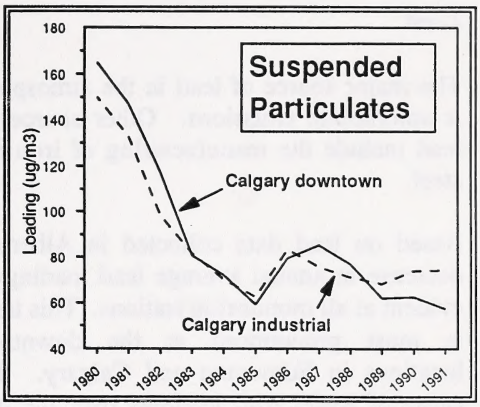
from petrochemical storage tanks in east Edmonton. Significant trends are not apparent at other monitoring stations.



Suspended Particulates

Common sources of particulates in the atmosphere are road dust, wind-blown soil, automobile emissions, industrial emissions, and smoke from recreational and forest fires.

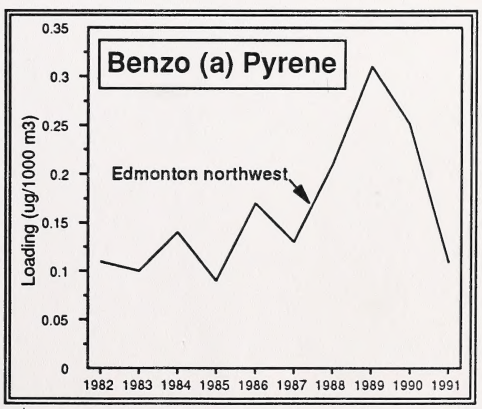
Significant decreases in suspended particulate loadings are indicated at the Edmonton central, Edmonton northwest, Ellerslie and all Calgary monitoring stations. This trend is most obvious at the Calgary downtown and industrial monitoring stations. The downward trend in suspended particulate loadings may be due to: (1) less road dust because of more paved roads; and (2) more efficient automobile engines.



Benzo (a) Pyrene

Benzo (a) Pyrene is contained in all types of smoke. Major sources of Benzo (a) Pyrene include vehicular exhaust, smoke from industrial sources, and smoke from recreational and forest fires.

Based on data collected from 1982 to 1990, a significant increase in annual average Benzo (a) Pyrene loadings is evident at the Edmonton northwest monitoring station. This increase is related to a greater traffic density in the vicinity of the monitoring station. Annual average Benzo (a) Pyrene loadings show a substantial decrease based on data collected from 1989 to 1991 at the Edmonton northwest station.



Lead

The major source of lead in the atmosphere is automobile emissions. Other sources of lead include the manufacturing of iron and steel.

Based on lead data collected in Alberta a decrease in annual average lead loadings is evident at all monitoring stations. This trend is most pronounced at the downtown locations in Edmonton and Calgary. The cause of lower lead loadings over the past 12 years is the decrease in the use of leaded gasoline. The suspended sale of leaded gasoline at domestic gas stations is likely the reason for decreased lead loadings in 1990 and 1991.